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Final Report

Quantifying the Costs of School Transportation

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ABSTRACT

While there has been attention to the costs of school busing, there has been little analysis of the multi-modal costs of school transportation and how those costs vary with the local environment. This study identifies the individual capital and operations cost items for each primary mode of transportation—automobile, school bus, bike, and walking—to allow for the consistent collection of data between states and school districts. Nine public elementary schools were selected from Florida representing areas with high, medium and low densities of student populations. The same criteria were used to select 11 schools in North Carolina representing medium and low density environments. School districts, published reports, and professionals associated with the design and planning of the study schools were consulted to gather cost and other relevant information. A school site visit was conducted to determine the travel mode split at each study school. Based on these results, the researchers have documented cases that suggest that school travel modes and costs are related to built environment characteristics surrounding a school site – the greater pedestrian accessible residential density around a school site, the higher the rates of walking, bicycling and driving to school and the lower rates of bus ridership. Correspondingly, dense accessible school sites exhibit lower public costs.

EXECUTIVE SUMMARY

Background of Research

During the 2010-2011 school year, the U.S. public school transportation system supported the safe daily arrival and departure of over 49 million K-12 students. Budget estimates suggest that the cost associated with operating and maintaining this school travel system is $22 billion annually. However, estimates of school travel costs only include operating and maintenance expenses for school buses. Ignored are the physical infrastructure costs of providing access by buses and cars to the school, family costs for driving students to school, and external costs, such as safety and air quality. As a result, researchers and practitioners lack critical information needed to choose school locations and provide multi-modal access at reasonable cost.

Methods

To address the lack of knowledge on the multi-modal costs of school transportation, we developed a framework to understand and categorize the expenses for school bus, private vehicle, and pedestrian school travel and applied this framework to estimate transportation costs at twenty recently-constructed public elementary schools in North Carolina and Florida. Our analysis assessed school travel cost variations across different local built environment contexts using a mix of empirical observations and simulation-based approaches. Based on these analyses, we developed a practitioner tool - a school travel cost calculator -- that accounts for the comprehensive public, private, and external costs of school transportation across all modes.

Findings and Implications

This study finds that school travel mode rates and corresponding school travel costs vary with local built environment factors, such as pedestrian network connectivity and the number of residential units within a half mile of school. In respect to travel mode, bus ridership rates decrease and passenger vehicle and walking and bicycling to school rates increase as residential densities increase and pedestrian connectivity improves. Corresponding to these travel mode differences, less dense, pedestrian inaccessible school sites exhibited higher public capital and operational costs than more dense, pedestrian accessible school sites. However, while public capital and operational costs decreased with higher levels of residential density and pedestrian access, private and external costs increased with higher density and pedestrian connectivity. Increases in private and external costs are attributable to higher passenger vehicle rates for homes located near schools that are not eligible for public busing service. As a result, private costs of school travel are higher for more dense and accessible schools due to higher rates of passenger vehicle ridership. Lastly, sizeable travel mode and per student travel cost differences were observed for comparable schools in NC and FL; overall, private and external costs were higher in Florida due to higher rates of passenger vehicle ridership and active school travel.

These results suggest that the density of residences and pedestrian connectivity within a half mile of a school influence school travel modes and corresponding school travel costs; the further away the majority of students live, the higher the motorized school travel modes and costs of transporting students to school. In addition, state-level policy differences in NC and FL, such as minimum busing distance eligibility, influence school travel costs. Longer minimum busing distances redistribute the responsibility of school travel to families, as observed in Florida's higher private passenger vehicle and active school travel rates (compared to North Carolina).

CHAPTER 1: INTRODUCTION

During the 2010-2011 school year, 49 million students were enrolled in public elementary and secondary schools (preK-12) in the United States (U.S. Department of Education, 2012). The school transportation system that supports the safe arrival and departure of these public students is substantial in its complexity and expense; for 2010-2011, the U.S. public school bus transportation system accounted for over $20 billion of primary and secondary educational expenditures (Cornman, 2013). Yet, these annual budget estimates only reflect yearly operating and maintenance expenses for public school bus transportation. Other cost categories, such as upfront infrastructure costs, private costs, and external costs, such as safety and air quality considerations, are unaccounted for in yearly budget estimates. Further, annual school travel budgets only account for busing operation and maintenance expenses and do not account for other school transport mode costs (i.e. private passenger vehicle and students that walk or bicycle to school).

This report contributes to the school travel and public investment literatures by documenting the multi-modal costs of developing and operating school travel systems. We develop a framework that accounts for the public, private, and external costs of school transportation across all modes and quantify these costs for 20 recently-constructed public elementary schools in North Carolina and Florida. Our analysis highlights how school transportation costs vary with school location, development patterns, travel patterns, and the state regulatory environment; and links to key planning and policy issues such as school siting and efforts to increase walking and biking to school. This paper begins with a background review of existing transportation cost allocation research, outlining relevant public investment studies. Then we describe our research approach and methodology for quantifying the full costs of public school transportation. Third, we review school travel data and total cost estimates for the study schools. Fourth, we conclude with a discussion of implications for school transportation, educational facility and community planning practice.

CHAPTER 2: BACKGROUND

An exploration of the full costs of school travel, and variation in school travel rates and costs by the local built environment surrounding a school, requires context on two issues. First, decisions about school location, known as school siting, directly impact the distance to school. The further a school is from a residence, the more likely that a student will require motorized travel school (i.e. public school bus or private passenger vehicle). Second, an inventory of the costs of elementary school transportation systems requires a full evaluation of all cost categories, which includes public costs, private costs and externalities to society.

School Siting

Clarence Perry played a significant role in the historic physical placement of schools in the center of neighborhoods and communities for residential developments in the U.S. Perry, drawing from the pragmatic aspirations of educational philosopher John Dewey, saw schools as central to planned urban life and cohesive communities. Through his position with the Regional Plan Association, Perry was able to influence the development of thousands of residential developments in the U.S. – placing schools in the very center of the neighborhood unit model. As a result, residential developments that accompanied American industrialization and middle class homeownership often had schools in the center of the community (Gillette, 2010).

When K-8 schools are located near or within residential developments, the distance to school can be relatively short. For example, in 1969, 41% of students between kindergarten and 8th grade lived within one mile of school (Beschen, 1972). The close proximity of students living near school had consequences for school travel and contributed to high rates of walking and bicycling to school; in 1969, 89% of children who lived within one mile of school walked or biked to school (Beschen, 1972).

The population and policy trends in the U.S. following WWII introduced several important shifts in the geography of schools. First, school enrollment policies began to reflect court-mandated integration, which often included intra-district school busing (Gans, Dentler, & Davidoff, 1964) . Second, maintenance and repair costs of older schools could be costly; some districts decided to build new schools rather than renovate existing schools (Council of Educational Facility Planners International, 2004). Third, an emphasis on larger campuses and learning environment necessitated the construction of new schools on larger parcels of land. Fourth, decisions on where to build new schools were guided by related two factors: the minimum acreage requirements legislated in many states, and the lower cost of land parcels on the development edge of many communities (McDonald, 2010)

School population size and location is directly related to school travel; the larger the school enrollment, the more land that is required and the larger the school catchment areas, which corresponds with longer distances from home to school. These trends in school policy and construction are reflected in school travel rates based on the 2009 NHTS. Of those children that lived within one mile of school in 2009, only 35% walked or biked to school compared to the 89% in 1969 (McDonald, Brown, Marchetti, & Pedroso, 2011) . *Figure 2-1* illustrates a common development pattern observed in the United States; in this example the school was constructed on a green field site located on the edge of the municipality’s residential development. The size of the school site, which refers specifically to school’s land acreage, impacts location of the school site and the distances from residences to the school entrance. Typically, the larger the school’s acreage the less pedestrian connected residential units will be located within a walking distance of the school (McDonald, 2010) .

Figure 2-1. School Siting Example from Study

Regional Context Perspective

School Campus Perspective

Categorizing Transportation Costs

Previous assessments of the full costs of transportation have identified three types of costs: public, private, and external (Anderson & McCullough, 2000; Delucchi, 1996) . For public and private costs, analysts distinguish capital costs from on-going operation and maintenance expenses. For example, Anderson and McCullough's inventory of public capital costs for the Minneapolis-St. Paul regional light rail system included the cost of land acquisition along the rail corridor and the light rail cars used for the light rail system. In a similar full cost analysis study, Delucchi and Murphy (1998) included the cost acquiring land to build off-street parking in their transportation system cost evaluation in the United States. This section reviews the cost categories used in other public, non-school transportation system evaluations in order to consider school travel cost elements that would be relevant and necessary for a full cost inventory.

The public costs of transportation systems include capital costs and the ongoing costs of operating and maintaining a transportation system for government agencies. For example, public capital costs may include the marginal or total cost of land required for a project, road and highway construction associated with material and labor, off-street parking facility construction costs, and the costs of acquiring transportation system components, such as buses and light rail cars. Examples of public operating and maintenance expenses include road pavement repair and maintenance costs, the labor costs of collecting highway user fees, the cost of subsidies to transit service, parking attendant salary and benefits, the salary and benefits of transportation police, fire and emergency protection, and the cost of licensing drivers. Collectively, public capital and operating costs are substantial. In their cost estimation of the Minneapolis-St. Paul transportation system Anderson and McCullough (2000) estimated that the annual cost of constructing and maintaining the Minneapolis-St. Paul street and highway system was between $1,340 and $1,735 million (1998 USD) and the cost of transit between $245 and $270 million (1998 USD) annually.

Private sector, or internal, costs represent expenditures by private citizens who are users of the transportation system. Private expenditures include out-of-pocket expenditures on vehicle ownership, maintenance, insurances, fuel, and other similar costs, but also include the value of personal travel time. The inclusion of in-vehicle travel time (IVT) in the evaluation of transportation project proposals can improve the accuracy of total transportation system cost estimates (Wardman, 2012) . Meta-analyses reviewing IVT estimates suggest that longer commuting trips are more costly than comparable shorter trips for leisure (Shires & De Jong, 2009; Wardman, 1998) . In their evaluation of the Minneapolis-St. Paul transportation system, Anderson and McCullough (2000) included monetary estimates for the value of commuting time travel using hourly wage estimates for the Minneapolis region. These hourly wage rates were then discounted based on trip type (i.e. commuting) and applied to IVT estimates for drivers in the transportation system. In addition to the value of in-vehicle travel time and vehicle maintenance, Anderson and McCullough included the internal costs of residential parking provision and personal costs of traffic crashes in their private user cost estimates.

External costs include the impacts of transportation that are not reflected in direct costs to the public or private sectors. For example, road congestion imposes costs on public traffic service provision and management (Litman, 2007). Further, emissions associated with transportation have impacts on local air quality, public health, and the world's climate that are unpriced in budgetary cost models (Delucchi, 1996). In the Minneapolis-St. Paul example, Anderson and

McCullough (2000) identified six external cost categories: traffic congestion; air pollution (decomposed to health and non-health related); traffic crashes; noise; petroleum-related incidents (i.e. robbery and fire); and community impacts of transportation projects. In respect to the cost of these externalities in Minneapolis, traffic congestion was projected to cost between $165 and $560 Million (1998 USD); traffic crashes between $150 and $320 Million; air pollution between $385 and $4,585 Million; noise between $5 and $29 Million; and fire and crime between $11 and $47 million per year (Anderson & McCullough, 2000)

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

This study estimates the full costs of elementary school transportation systems and uses that information to 1) analyze cost variation across built environment contexts and 2) introduce a practitioner tool for comparing school site transportation costs. The multi-modal costs of school transportation were collected for 20 recently constructed elementary schools in North Carolina and Florida. North Carolina and Florida were selected for the study due to researcher familiarity and recent rates of high growth in population that require the construction of new schools in both states. We focused on recently-constructed school sites in order to inventory and document cost factors that would be relevant to school and land use planners who are often responsible for advising on school site location decisions. Historically, school siting decisions are made without a detailed understanding of the full pupil transportation system costs associated with school siting due, in part, to the absence of research on the relationship between school site location and school travel costs.

3.1 Site Selection

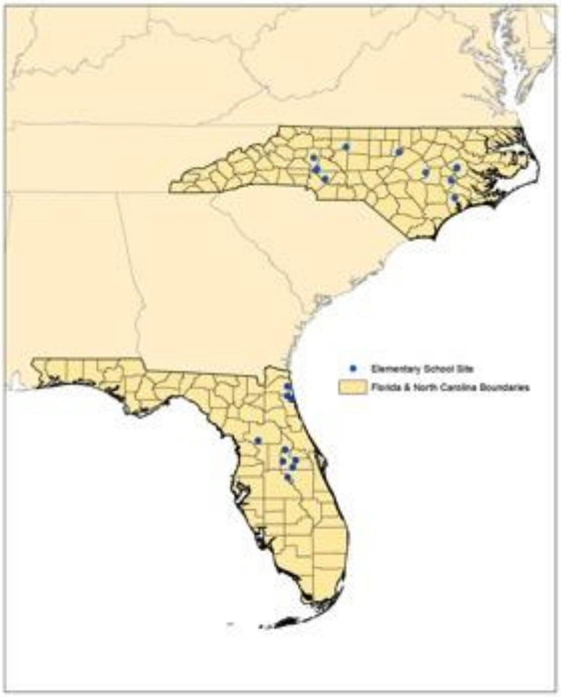
Previous research highlights the influence of pedestrian connectivity and the number of nearby residential units on school travel patterns (Larsen et al., 2009; McDonald, 2007). Thus, the schools for this study were selected using built environment categories that reflect residential density and pedestrian accessibility to the school site.

The three built environment categories were constructed: 1) schools with less than 100 residential units accessible to the school within a half mile walk; 2) schools with between 101 and 500 pedestrian accessible residential units within a half mile walk of the school; and 3) schools with greater than 500 housing units within a half mile walk of the school. Local built environment characteristics were collected within a half-mile buffer based on the entrance of the school driveway. Residential densities were calculated as the number of residential units within a half-mile buffer (aerial) of the school's driveway entrance. The density of multi-family housing units were estimated using one of two multi-family structures – smaller housing developments were estimated to have six multifamily residences per structure and larger developments 24 residences per structure. Pedestrian connectivity of each residential unit within the half-mile buffer was defined as the presence of continuous sidewalk from the home to the school driveway entrance, regardless of number of street crossings. The density and accessibility calculations were conducted using spring 2013 Google Earth Pro aerial imagery.

In addition to local built environment characteristics, eligible study schools were public school sites that enrolled students using geographic assignment methods (i.e., students were assigned to a specific school, and the school was not a magnet school) and located in a metropolitan area with available school travel and cost data. Using this criteria, Southeastern Transportation

Research, Innovation, Development and Education Center (STRIDE) researchers identified a total of 49 eligible elementary school that opened between 2009 and 2012 in Florida (21) and North Carolina (28). To ensure diversity of development patterns in the project's sample of school sites, 20 schools were included in the study; 11 North Carolina schools and 9 Florida schools. *Figure 3-2* displays the location of study sites. *Appendix A* lists the participating schools in both states.

Figure 3-2. Florida and North Carolina School Site Selection



3.2 Multi-modal School Transportation Cost Collection Framework

The research team developed a full cost framework for multi-modal school transportation costs based on the work of Anderson and McCullough (2000), Sisiopiku, et al. (2013), and Delucchi and Murphy (1998). Using the Sisiopiku, et al. (2013) framework as a template (*Appendix D*), our school travel cost framework focuses on four distinct cost categories: public transportation-related capital expenses on the school campus; public operating and maintenance expenses related to transporting students; private costs of time and passenger vehicle operation; and external costs across all school travel modes, specifically due to traffic congestion, air quality impacts and loss of life. In addition to providing a picture of the full social costs of school travel by school, the social cost framework affords the evaluation of costs by school travel mode, such as the full costs of school bus transportation or private passenger vehicles, and variation in school travel costs by school site local built environment characteristics. *Table 3-1* provides examples of school travel costs by cost category and travel mode; *Table 3-2* inventories the costs included in the study, and includes detailed information pertaining to relevant school travel mode, unit cost, measurement, and methodological source.

Table 3-1: Cost Category and Travel Mode Overview

School Travel Mode	Public Capital Costs	Public Operating & Maintenance Costs	Private Operating & Maintenance Costs	External Costs
School Bus	Bus acquisition; School transport system infrastructure (pavement, signals)	Bus driver pay; Fuel costs; School transport infrastructure upkeep		Traffic Congestion; Air Quality Impacts; Loss of Life
Passenger Vehicle	School transport system infrastructure (pavement, signals)	School transport infrastructure upkeep	Value of parental drive time; Cost vehicle operation and maintenance	Traffic Congestion; Air Quality Impacts; Loss of Life
Walking & Bicycling	School sidewalk network; Pedestrian crossing infrastructure	Crossing guards		Traffic Congestion; Air Quality Impacts; Loss of Life

Public Capital Costs

For the majority of public capital expenses, we identified per-unit construction costs for each of the key elements; e.g. bus driveway, auto driveway, and sidewalks; and then measured the size of each of these elements at each study site. We did not attempt to identify the actual costs of construction since it would be impossible to isolate the costs of a particular sidewalk from those of the overall project. Thus, surface transportation cost items, such as sidewalks, were estimated based on either 1) surface coverage and a per-square-foot cost equivalency, or 2) per unit costs, as in the case of school traffic lights. Infrastructure costs were then assigned to corresponding school travel modes based on the mode served; separate costs were estimated for school entrance, driveway, parking and unloading by both school bus and passenger vehicle. In instances where infrastructure is used by more than one mode, as in the example of passenger unloading sidewalk sections, capital costs are shared by bus and passenger vehicle travel modes. Vehicle acquisition costs were an exclusive cost attributable to school bus ridership.

To compare public capital costs with the three other cost categories, we annualized all capital expenditures. The approach, adapted from Delucchi and Murphy (1998), utilizes the replacement value of capital infrastructure such as school buses, entrance drives, parking lots and sidewalks, converted into an equivalency of annual costs over the life of the capital using a social discount rate. For this analysis, we presumed that the total initial capital investment was equal to the net replacement value, the life of the capital investment was 20 years (*t*) and the social discount rate was 3.5% (*i*) (White House Office of Management and Budget, 2003). Annualized capital costs (*ACC*) were calculating using the following formula:

$$\text{ACC} = \frac{\text{NRV} * i}{1 - (1+i)^{-t}}$$

By using a total initial capital investment estimate for Net Replacement Value (NRV) that includes school site transportation infrastructure construction and school bus acquisition, our approach accounts for depreciation of capital investments. Correspondingly, we do not include separate depreciation costs for infrastructure or school buses as line items elsewhere.

Public Operating and Maintenance Costs

For public operations and maintenance expenses, we employed several strategies. When per-unit costs were well-known, e.g. per-mile costs of private vehicle travel, we utilized them. However, for many of these costs, there were no previous estimates of the costs. For example there was no published information on the costs of school bus drivers in multi-tiered districts, school bus security or the costs per school bus mile traveled. In these cases, we requested the actual costs from the school or district. Per-student insurance and licensure fees were estimated using cost data provided by the North Carolina Department of Public Instruction (NC DPI). Due to the lack of Florida insurance information, the NC DPI per pupil cost estimate was used for schools in both Florida and North Carolina.

Private Operating and Maintenance Costs

Private vehicle operation and maintenance costs are important cost items not traditionally captured in school travel cost estimation. This study carefully considered and estimated two private school travel cost elements based on previous full cost estimation efforts by Anderson and McCullough (2000): the value of parental time for driving students to school in a private vehicle and the private cost for vehicle operation and maintenance during the school travel segment of a private vehicle school trip.

In order to estimate the total private cost of parental driving time, we needed to collect or calculate several school travel variables: 1) the average distance from home to school; 2) the average number of daily trips to school; 3) the number of passenger vehicles riders at a school; 4) the average speed of a vehicle driving to school; and 5) the hourly after-tax value of time based on the prevailing wage rate. The average distance from home to school is a relatively common school travel variable available in many school districts. *Appendix C* highlights our method for estimating this average distance when no such measure was available. Similarly, the number of passenger vehicle riders at a school is a statistic many districts have available and was verified during school site visits. It is assumed that the average speed of vehicles driving to school is 20 mph. Methods for estimating the number of daily trips to school and the hourly value of time are discussed below.

The number of daily trips to and from school is variable by school context and familial factors. According to the 2009 National Household Travel Survey, approximately 60% of passenger vehicle trips to and from school were linked with other passenger vehicle trips (i.e. on the way to work; running errands). In linked trips, a return home from school drop-off would not be required. An additional 40% of passenger vehicle trips from home to school were special trips that existed solely to drop off or pick up a student (McDonald et al., 2011). In total, linked and special passenger vehicle trips to school accounted for 30.0 billion miles and 6.6 billion vehicle trips in 2009 (McDonald et al., 2011). Using these 2009 NHTS school travel statistics, we estimate that, on average there are 2.8 trips per household per day to and from school.

60% x 2 trips per day + 40% x 4 trips per day = 2.8 trips per day

The travel time associated with driving a child to school in a private passenger vehicle has value. Research indicates that the value of travel time in the U.S. is context and mode sensitive; for private vehicle drivers in non-highway, off-peak conditions the value of travel time ranges between 35% and 60% of after-tax hourly wages (Anderson & McCullough, 2000; U.S. Department of Transportation, Federal Highway Administration,) . Litman (2007) recommended travel time values of 50% of the prevailing wage rate for adult personal vehicle drivers. For this study we use Litman's recommended 50% of prevailing wage estimate, which falls within the USDOT value of travel time range (Litman, 2007). According to the U.S. Bureau of Labor Statistics, the national pre-tax hourly wage was $24.05 in August 2013 (U.S. Department of Labor, Bureau of Labor Statistics, 2013). Accounting for federal and state-level taxes, the average after-tax hourly rate for North Carolina residents would be $15.30. As Florida residents do not pay an income tax, this hourly in-vehicle rate was used for schools in both North Carolina and Florida for the purpose of cost comparison. Using an estimate of 50% of after-tax hourly income for the value of in-vehicle school travel time, the private cost of travel time for parents driving their children to school is about $7.65 per hour.

Total Passenger Vehicle Driving Hours (School Level, per Day) =

$$\frac{\text{Average Home to School Distance} \times 2.8 \text{ Daily Trips} \times \text{Number of Passenger Vehicle Riders}}{20 \text{ Mph}}$$

Private Cost Estimate for Parental Value of Drive Time (School Level, per Year) =

Total Passenger Vehicle Driving Hours x $7.65 per Hour x 185 Days

Private cost estimates of the value of travel time for adult drivers does not include time costs associated with travel delays due to congestion, which are addressed separately by external congestion costs. In addition, our travel time estimate does not include the time necessary to acquire a vehicle, maintain a vehicle, nor obtain formal training necessary to drive a vehicle. Furthermore, school travel time estimates for parents of children that walk or bicycle to school are not included based on the rationale that this time expense is optional for parents.

In addition to the value of parental drive time, the financial cost of operating and maintaining a private passenger vehicle to drive a student to school is calculated using the 2013 AAA estimate for average vehicle operation and maintenance costs per mile, $0.2196 per mile(Automobile Association of America, 2013). This estimate accounts for operation and maintenance related costs, including gasoline, vehicle maintenance, and tire wear. Vehicle acquisition and insurance costs are not included, as these items are fixed costs regardless of vehicle miles traveled.

Of note, this study does not account for value of parental time for active travel to school due to lack of data on the parent active school travel presence and questions about how that time should be valued. Investigation of this topic is an area for future research.

External Costs

For external costs of school travel to the general public, we used estimated cost factors associated with three categories: traffic congestion; environmental degradation and personal safety. These three external cost sub-categories were comprised of cost items that used either vehicle miles traveled or number of trips by school travel mode to estimate external costs due to school travel. As an example, the total external cost associated with increased traffic congestion was estimated for vehicle miles traveled by school bus and passenger vehicle.

In the case of personal safety costs, cost estimates were calculated using loss of life and severe injury crash statistics based on the number of school trips per school travel mode. These mode-based monetary cost estimates are based on published statistics of safety costs that evaluated school-related crashes in North Carolina (McDonald et al., 2015). This cost of school travel safety cost research is included in *Appendix E* of this report and was a component of the STRIDE-funded project.

As *Table 3-2* indicates, some cost elements were not included in this analysis. For example, we did not include the private sector capital costs of vehicle or bicycle ownership. We ignored these costs because we presumed that the families made their vehicle ownership decision independent of their school travel needs. Also excluded from the analysis were the capital costs associated with school district bus maintenance facilities. This cost was excluded because all districts would need to maintain such a facility no matter the school travel patterns at specific schools. We also ignored the value of children's school travel time. Further, we did not include global climate change impacts in our external cost estimates due to the complexity of such estimation.

Table 3-2: Cost Data Elements in the Full Cost Framework

Public Capital Costs					
	Related Mode	**Unit Costs**	**Unit**	**Source**	**Data Collection Method**
Bus Driveway	School Bus	$4.21	Square Foot	RSMLN G2010-210-1520	ArcGIS 10.1
Auto Driveway	Auto	$4.21	Square Foot		ArcGIS 10.1
Parking Lot	Auto	$915	Parking Space	RSMLN G2020-210-1500	ArcGIS 10.1
Unloading Area	School Bus	$4.33	Square Foot	RSMLN G2010-210-1520	ArcGIS 10.1
Unloading Area	Auto	$4.33	Square Foot		ArcGIS 10.1
Sidewalk Connect	Auto	$4.33	Square Foot	RSMLN G2030-110-1580	ArcGIS 10.1
Sidewalk	Walk	$4.33	Square Foot		ArcGIS 10.1
Bike racks	Bike	$250	Bike Racks	Unit based on median cost of bike rack per district response	District Questionnaire
School Buses	School Bus	$85,000	School Buses	Unit cost based on average school bus acquisition cost per district response	District Questionnaire
Physical Security System Install	School Bus	$1,500	School Buses	Estimate based on average system acquisition cost per district response	District Questionnaire

Public Operations Costs					
	Related Mode	**Unit Costs**	**Unit**	**Source**	**Data Element**
Fuel	School Bus	$0.49	VMT	Unit cost based on 6.0 mpg school bus; $2.94 per diesel gallon as of 8/13	District Questionnaire
Crossing Guards	Walk	$3,801	Crossing Guard	Unit cost based on 2.0 hrs per day; 185 school days;	District Questionnaire
Bus Drivers	School Bus	$6,812	School Bus	Unit cost based on 4.0 hrs per day; 185 school days;	District Questionnaire
Insurance and Licensure Fee	School Bus	$7.42	Student	Unit cost based on average of 2007-12 tort claims paid for injury by NC DPI	District Questionnaire
Detection and Surveillance	School Bus	$125	School Bus	Estimate based on average system subscription cost per district response	District Questionnaire
GPS Tracking	School Bus	$150	School Bus		District Questionnaire

Public Maintenance Costs					
Infrastructure Routine Maintenance	School Bus	$2.84	Linear Foot	As reported by Sacramento Area Council of Governments (2012)	ArcGIS 10.1
Infrastructure Routine Maintenance	Auto	$2.84	Linear Foot		ArcGIS 10.1
Vehicle Routine Maintenance	School Bus	$14,529	School Bus	All-inclusive figure based on 3 year average reported by Michigan School Business Officials (2011)	District Questionnaire

Private Capital Costs	
Private Vehicles	[not included]
Bicycles	[not included]

Private Operations Costs					
	Related Mode	**Unit Costs**	**Unit**	**Source**	**Data Element**
Vehicle Operation and Maintenance	Auto	$0.2196	VMT	Unit cost based on AAA estimate for vehicle operation and maintenance costs per mile (2013)	District Questionnaire
Value of Parental Travel Time	Auto	$0.3825	VMT	Unit cost based on value of time estimate using average speed of 20 mph and $7.65 after-tax hourly pay.	District Questionnaire
Value of Child Travel Time	[not included]				

External Costs					
	Related Mode	**Unit Costs**	**Unit**	**Source**	**Data Element**
Traffic Congestion	School Bus	$0.0063	VMT	Extracted from Table V-23 by FHWA (1997); Rural Low Estimate	District Questionnaire
Traffic Congestion	Auto	$0.0034	VMT		District Questionnaire
Traffic Service	School Bus	$0.007	VMT	Extracted from Table 5.8.7-1 by Litman and Doherty (2009, 5.8-5); Rural Estimate	District Questionnaire
Traffic Service	Auto	$0.007	VMT		District Questionnaire
Non-GHG Air Quality Impacts	School Bus	$0.013	VMT	Extracted from Table 5.10.7-1 by Litman and Doherty (2009, 5.10-27); Rural Estimate	District Questionnaire
Non-GHG Air Quality Impacts	Auto	$0.004	VMT		District Questionnaire

GHG Air Quality Impacts	School Bus	$0.66	VMT	Extracted from Table 5.10.7-3 by Litman and Doherty (2009, 5.10-27); Rural Estimate	District Questionnaire
GHG Air Quality Impacts	Auto	$0.132	VMT		District Questionnaire
Noise	School Bus	$0.04	VMT	Extracted from Table V-22 by FHWA (1997); Rural Low Estimate	District Questionnaire
Noise	Auto	$0.00	VMT		District Questionnaire
Climate Change	[not included]				
Safety	School Bus	$0.16	Trips	Extracted from Table 6 by McDonald et al. (2014)	District Questionnaire
Safety	Auto	$1.13	Trips		District Questionnaire
Safety	Walk	$0.98	Trips		District Questionnaire
Safety	Bike	$1.87	Trips		District Questionnaire

3.3 Data Collection Methodology

To estimate expenditures on transportation, we collected data on the physical layout of the school campus, student travel mode and distances, and school bus provision and associated costs from the school and school district. A copy of the data collection instrument is attached in *Appendix B.*

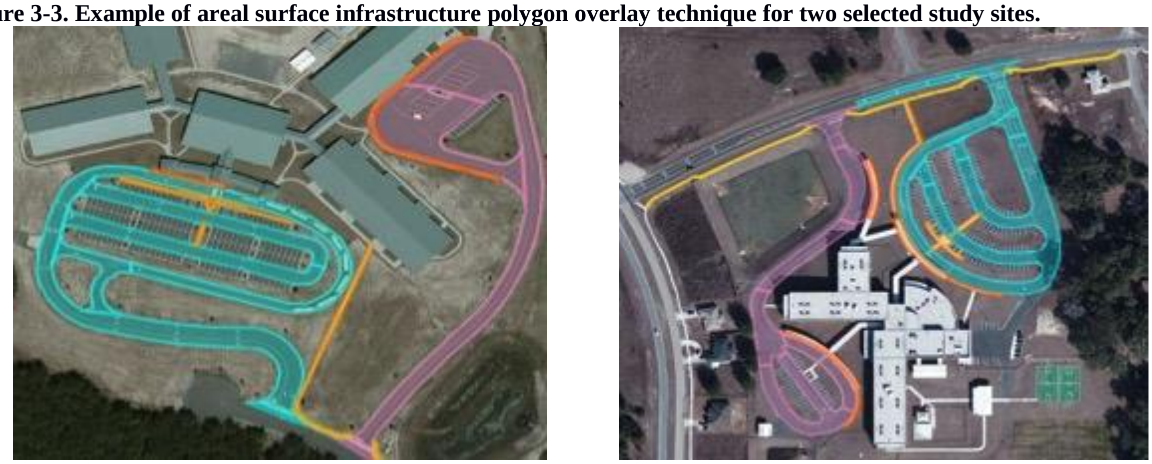
School Bus Acquisition and Operation Information

This study collected information on school bus acquisition, operation and maintenance cost elements using a standardized questionnaire formatted in Microsoft Excel. Communication was digital; the questionnaire was administered and submitted via email. The data collected via the questionnaire administered to school staff included: 1) the number of buses that serviced a school; 2) the number of schools that shared a bus through routing efficiency or staggered use (i.e. number of tiers); 3) presence of on-board physical security systems; and 4) school travel operation labor, including bus drivers and crossing guards. Data reported by school officials in the questionnaire were verified by the project team during site visits.

School Campus Transportation Infrastructure

Each school site was constructed with varying levels of transportation-relevant infrastructure, including paved roadways, driveways, sidewalks and parking areas. All of the schools in the study were designed with separate driveways and entrances for school buses and autos. This design strategy allowed us to allocate the infrastructure costs by mode. Square and linear footage data were collected using GIS to account for the costs of paved infrastructure. Using ArcGIS 10.1 software, the project team overlaid polygons on each school's sidewalk, parking lot and road networks to obtain square footage estimates for each surface type. The questionnaire was used to collect data from school staff on the presence of bicycle racks, pedestrian crossing signals, traffic signals, and overhead lighting for the school entrance, driveway, parking area and unloading zones.

Figure 3-3. Example of areal surface infrastructure polygon overlay technique for two selected study sites.



Princeton Elementary School in Princeton, NC. **Marion Oaks Elementary School in Ocala, FL.**

Note for Figure 3-3. **The blue polygon identifies school driveway and unloading zone surface areas for passenger vehicles; the purple polygon identifies school driveway and unloading zone surface areas for school buses.**

School Travel Mode and Distance to School Data

The school travel mode data includes pupil transport rates across school travel modes and distances from home to school for each student. The specific data collected on school travel mode and distance included: 1) the school-level modal split for school bus riders, passenger vehicle riders, pedestrians and bicyclists, 2) the number of school trips for the enrolled population, 3) the daily vehicle miles traveled for school buses and passenger vehicles, and 4) the residential density and average home-to-school distance for the enrolled school population. Travel mode and distance questions were included in the standardized questionnaire administered to school staff in both states; however, methods for on-site school travel data collection were different for schools in North Carolina and Florida, as discussed below.

In North Carolina, school travel mode and bus data were obtained from the Transportation Information Management System (TIMS) maintained by the NCSU Institute for Transportation Research and Education (ITRE). TIMS is a statewide geographic information system (GIS) that helps school districts maintains and improve efficiency in school bus transportation. Each North Carolina school district operates standardized, comprehensive computer-assisted school bus routing and scheduling software. As a result, TIMS data includes the number of school buses used, daily school bus vehicle miles traveled (VMT), school travel mode splits, and average home-to-school distance statistics. These results were cross-referenced with district reported data and in-person observational modal counts at each school site conducted by the study team.

In Florida, questionnaires submitted by participating school district transportation department staff provided data on the number of school buses used, the daily school bus VMT, school travel mode splits, and mode-specific information. Data were then cross-referenced through in-person observational modal counts at each selected school site by the study team. This study did not have access to data on the home location of students for the study schools within the state of Florida. However, data with the locations of elementary students during the 2007-08 school year for Hillsborough, Orange, Pasco and Seminole counties were available. Distance to school estimates were estimated for each student. The method for estimating average home to school distances for Florida schools is detailed in *Appendix C*.

3.4 Analysis of Transportation Costs

Inventorying the full social costs of elementary school transportation gives important insight into the cost elements of local transportation infrastructure associated with school travel. Our analysis investigated how these costs varied by school location and local travel patterns. The school travel cost inventory was also used to assess how busing children that live near school impacts public sector expenditures (McDonald et al., 2014) . Specifically, the study simulated three different travel mode scenarios for students within one mile (100% bused, 50% bused, and 0% bused) for four different schools that vary by the percentage of students living within one mile of the school. Modeling was conducted by the Pupil Transportation group at North Carolina State's Institute of Transportation Research and Education using EduLog software. A full description of the methods and results of that analysis is available in *Appendix F*.

3.5 Development of a Practitioner Tool

The research team developed a practitioner tool for educational facility planners and school travel administrators using the methodology included in this study and results obtained from responses to the school travel cost questionnaire. The tool is intended to empower practitioners and education decision makers to compare school travel cost estimates for two different school sites. The tool enables users to consider both the surrounding built environment characteristics of the potential school site as well as the percentage of students that are projected to live within one-half mile of the school site.

4. Results

The results of the study are presented in the following sections and afford comparative evaluation of school travel rates and costs by state-level and built environment context. Section 4.1 presents the multi-modal school transportation data and evaluates school travel modal variation by state and local built environment context. Doing so allows us to compare school travel patterns between North Carolina and Florida and to look within each state to understand how school travel rates varied with pedestrian accessibility and residential density context. Section 4.2 presents school travel cost results and analysis focused on cost variation by state and local built environment context. Standardized per-unit costs were applied in analysis of school travel costs so that variation in outcomes were not affected by idiosyncratic factors such as labor rate differentials between the two states or the costs of construction materials.

4.1 School Travel Mode Rates

The school travel rates were collected for three modes of travel to school: bus riders, private passenger vehicle riders, and walkers and bicyclists, referred to in the results table as active travel. These results depict the school travel system for the elementary study sites in North Carolina and Florida and are presented in *Table 4-1*.

Table 4-1. School Travel Mode Splits for Selected School Sites in NC and FL.

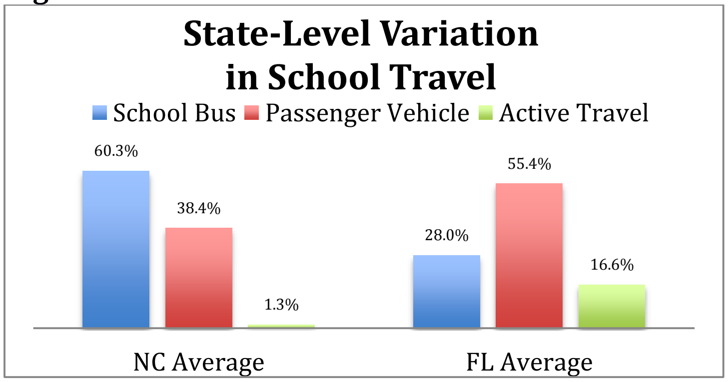
North Carolina School Travel Mode Splits			
Number of Pedestrian Accessible Housing Units w/in 1/2 Mile of School	**School Bus**	**Passenger Vehicle**	**Active Travel**
Low: < 100	67.0%	32.9%	0.0%
Moderate: 101 - 500	49.2%	47.3%	3.4%
High: > 500	n/a	n/a	n/a
State Average	60.3%	38.4%	1.3%

Florida Travel Mode Splits			
Number of Pedestrian Accessible Housing Units w/in 1/2 Mile of School	**School Bus**	**Passenger Vehicle**	**Active Travel**
Low: < 100	39.1%	54.6%	6.3%
Moderate: 101 - 500	36.2%	53.7%	10.0%
High: > 500	20.6%	56.3%	23.1%
State Average	28.0%	55.4%	16.6%

State-Level Variation

Differences in school travel modal rates by state may provide insight into the influence of state-level policies and socio-cultural context on school travel. The school travel mode results show remarkably different school transportation systems operating in North Carolina and Florida; the school bus ridership average for selected North Carolina schools is 60%, compared to 28% of students in the Florida schools. Correspondingly, passenger vehicle and active school travel (pedestrian and bike) rates are also different; the North Carolina schools in our sample had 38% passenger vehicle rates compared to 55% for Florida schools, and North Carolina schools had 1% active school travel rates compared to nearly 17% in Florida. *Figure 4.1* illustrates these state-level average differences in school travel rates for study schools.

Figure 4.1



Direct comparison of the built environment categories by state suggests that the observed difference in state-level averages extend to the density categories. While the trends in school travel across density categories in both states suggest that increased local residential density decreases bus ridership and increases active school travel rates, the magnitude of these increases in walking and bicycling to school vary by state. Comparison of the least dense residential schools in North Carolina and Florida, those schools with less than 100 pedestrian accessible residential units within a half-mile buffer, shows substantial differences in travel mode rates. North Carolina's least dense schools averaged higher bus rider rates (67%) than the comparable Florida schools (39.1%). This 28% difference was redistributed across passenger vehicle rates, with North Carolina schools averaging 32.9% to Florida schools 54.6% average (21.7% difference), and active school travel (6.3% difference).

Comparison of the moderate density schools in North Carolina and Florida, those schools with more than 100 but less than 500 pedestrian accessible residential units within a half-mile buffer of the school, shows differences between the states. North Carolina moderate density schools averaged higher bus rider rates (49.2%) than the Florida schools (36.2%). This 13% difference was redistributed across passenger vehicle rates, with North Carolina schools averaging 47.3% to Florida schools 53.7% average (6.4% difference), and active school travel, with North Carolina schools averaging 3.4% to Florida schools 10.0% average (6.6% difference).

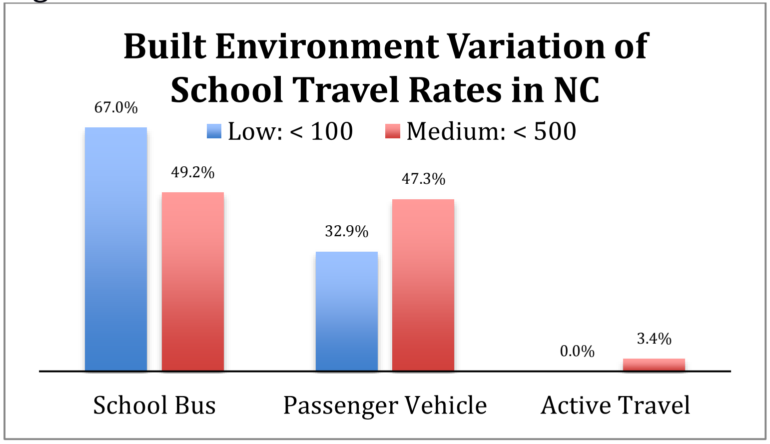
Florida had a third density category that was unobserved in the North Carolina school sample. This third density category consisted of schools with more than 500 pedestrian accessible residential units within a half-mile buffer of the school. Among the North Carolina schools, the school with the highest density had only 351 pedestrian accessible residential units within a half-mile of the school. These high density, high pedestrian accessibility schools showed substantial differences from the other less dense, less accessible schools in the study. These schools averaged 20.6% bus ridership, 56.3% passenger vehicle ridership, and 23.1% active school travel. These rates necessitate a comparison of built environment categories.

Built Environment Variation

Differences in school travel rates by pedestrian accessible residential unit density categories within each state may provide further insight into the influence of the local built environment on school travel mode rates. As noted earlier, school bus ridership rates decrease for schools in North Carolina and Florida as pedestrian accessible residential unit density increases. Of importance is an understanding of which school travel modes (i.e. bus, passenger vehicle or active school travel) change with increases to pedestrian accessible residential unit density.

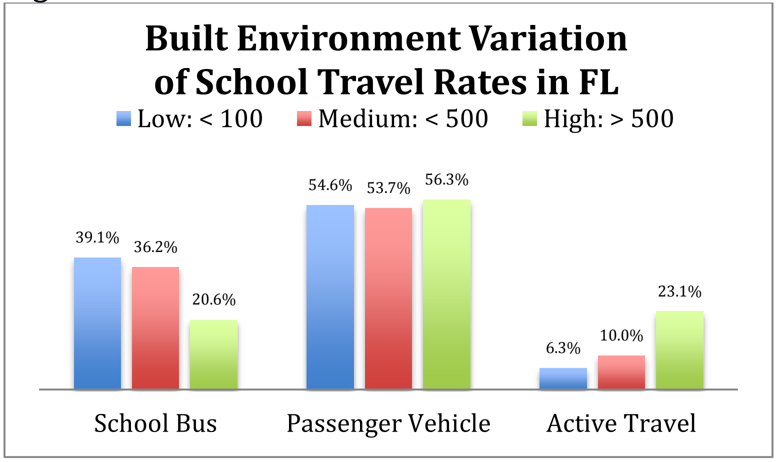
In North Carolina, school bus ridership decreases from 67.0% in the least dense schools to 49.2% in the moderate density schools a 17.8% decrease). These students are primarily redistributed to passenger vehicles for school travel, with a 14.4% increase in passenger vehicle ridership from 32.9% (least dense) to 47.3% (moderate density). Active school travel rates in North Carolina also increase with residential density increases; walking and bicycling to school increased from 0.0% in the least dense schools to 3.4% in the moderate density schools. *Figure 4.2* illustrates school travel mode rate variation across two built environment categories in North Carolina.

Figure 4.2



In Florida, school bus ridership rates also decrease as density increases; bus rider rates fall from 39.1% in the least dense schools to 36.2% in the moderate density schools to 20.0% in the most dense schools. Of note, as bus rider rates fall, passenger vehicle rates appear relatively stable across density levels; it is the active school travel rates that increase substantially with residential density increases. The least dense schools in Florida averaged 6.3% active school travel, whereas the moderate density schools averaged 10.0% walkers and bikers and the most dense schools averaged a substantially higher 23.1%. *Figure 4.3* illustrates these variations in school travel mode rates across three built environment categories for schools in Florida.

Figure 4.3



4.2 School Transportation Costs

One would anticipate that difference in school travel rates for bus ridership, passenger vehicle ridership, and active school travel would translate to difference in annual costs for school travel. The school travel cost results collected in this study monetize the comprehensive, full social costs of school travel and include costs across the four cost categories described earlier: public capital costs, public operating costs, private costs and external costs. The results for elementary school study sites in North Carolina and Florida are presented in *Table 4-2* and *Figure 4-4*.

Table 4-2. School Travel Costs by Cost Category for Selected School Sites in NC and FL.

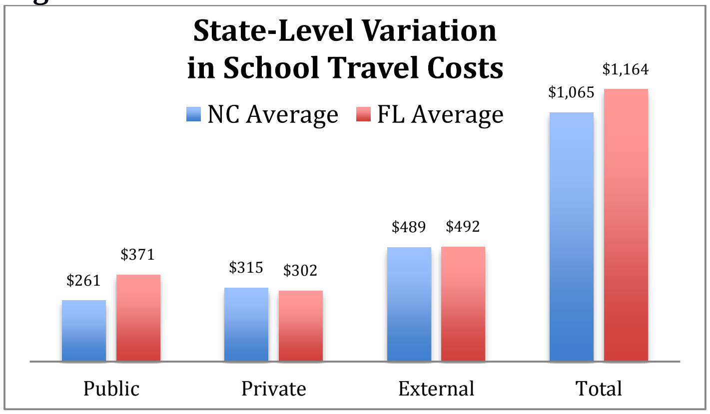
North Carolina School Travel Costs per Student						
Accessible Housing Density	Public Capital	Public Operating	**Public Total**	**Private**	**External**	**Total**
Low: < 100	$135	$249	$383	$220	$318	$922
Medium: < 500	$105	$195	$300	$271	$386	$957
High: > 500						
State Average	$123	$228	$352	$240	$344	$935

Florida School Travel Costs per Student						
Accessible Housing Density	Public Capital	Public Operating	**Public Total**	**Private**	**External**	**Total**
Low: < 100	$150	$414	$564	$371	$560	$1,495
Medium: < 500	$104	$217	$321	$227	$388	$936
High: > 500	$112	$202	$314	$304	$504	$1,121
State Average	$119	$252	$371	$302	$492	$1,164

State-Level Variation

Comparison of the total, comprehensive social costs of school travel in North Carolina and Florida suggest an annual difference of $229 per student, with the North Carolina schools averaging $935 per student and the Florida schools averaging $1,164 per student. Within this total annual cost is the annual public cost of school travel, which reflects both public capital and public operation and maintenance costs. While North Carolina had higher school bus ridership rates (60.3% to 28.0%), surprisingly the schools in our study had lower annual public costs ($352 to $371). The private and external cost averages were also higher for Florida due to higher private passenger vehicle ridership and active school travel levels. Direct comparison of density category average costs may help to explain these variations. *Figure 4.4* illustrates these state-level average differences in school travel rates for study schools.

Figure 4.4



Comparison of the least dense residential schools in North Carolina and Florida shows substantial differences in school travel mode systems and costs; the annual total school travel costs were estimated at $922 and $1495, respectively. For a school with 500 students, these per student cost differences would equate to $286,500 per year. This $573 per student annual difference is attributable to factors across the four school travel cost categories, but strongly associated with the higher bus rider rates in North Carolina and higher passenger vehicle and active school travel rates in Florida. The least dense schools in North Carolina averaged $135 per student for public capital costs, which was $15 less than the comparable Florida schools ($150 per student). However, the least dense North Carolina school had an estimated annual public cost of operation and maintenance of $249 per student, which was $165 less than the average estimated for the Florida schools ($414 annually). Further, private costs in North Carolina were $220 per student, $151 less than the $371 per student average in Florida. Finally, external costs in North Carolina were $318 per student compared to $560 per student in Florida's least dense schools.

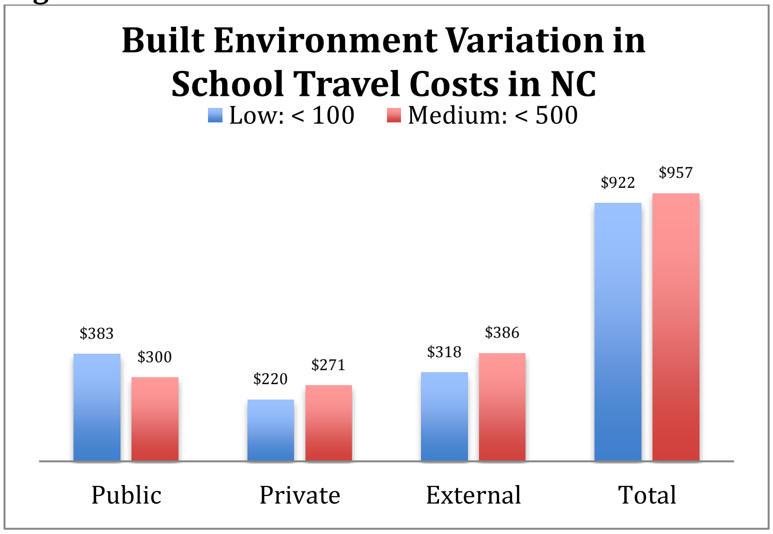
While the comparison of the least dense schools in North Carolina and Florida suggest different systems and costs, comparison of the full school travel costs for moderate density schools suggest very similar school travel systems and costs. The total school travel costs for North Carolina's moderate density schools were estimated to be $956 per student annually, which was $19 per student more than the comparable Florida average of $936 per student annually. The public capital costs were nearly identical, with North Carolina schools averaging $105 per student and Florida averaging $104 per student. The public operating and maintenance costs were also relatively close, with schools averaging $195 per student and Florida schools averaging $215 per student. The private costs for North Carolina moderate density schools ($271) were actually quite a bit higher than comparable Florida schools ($227). The external costs for North Carolina and Florida moderate density schools were also very close, at $386 and $388 respectively.

Built Environment Variation

As noted in the school travel results, decreases in school bus ridership accompany increases in pedestrian accessible residential unit density for elementary schools in both North Carolina and Florida. Corresponding decreases in annual public costs, comprised of public capital and public operating costs, are observed across density categories for schools in both states. Similarly, increases in private and external costs are observed as densities increase for schools in both states. As a result, the total annual costs of school travel appear to vary substantially from state to state and by local built environment densities.

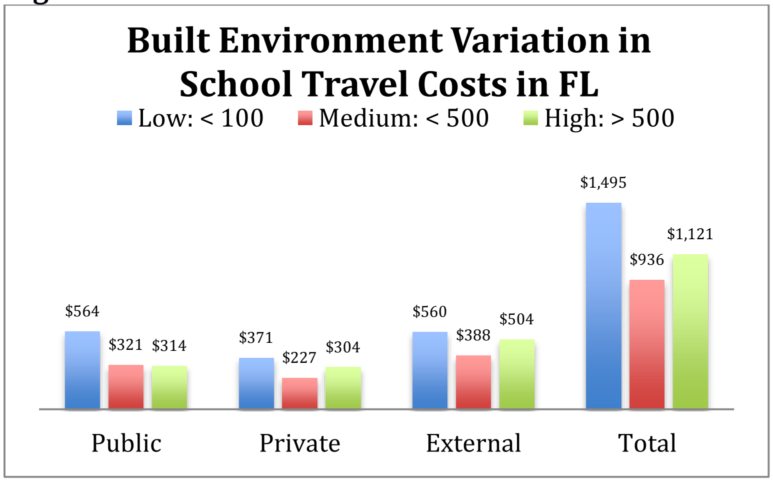
In North Carolina, the annual public cost difference between the least and most dense categories were $83 per child per year, or the difference between $383 per student and $300 per student. As pedestrian accessible residential density increased, annual per student public costs decreased. However, there appears to be a cost transference from annual public costs to private and external costs as density increases. With the increase in density from low to moderate dense schools we estimated an increase in private costs per student from $220 annually to $271 annually ($51 difference). Similarly, we estimated an increase in external costs from $318 for North Carolina's least dense schools to $386 for the densest schools ($68 difference). *Figure 4.5* illustrates variation in school travel costs across two built environment categories in North Carolina.

Figure 4.5



In Florida the total costs of school travel varied substantially between the three density categories and suggest three distinctly different local contexts and corresponding school travel systems. The total annual school travel costs for Florida's least dense category were estimated to be $1,495 per student, which was $559 more than the moderate density average for Florida schools in the sample ($936). These differences are attributable to the low density category's higher average public capital costs ($150 to $104), higher average public operating and maintenance costs ($414 to $217), higher private costs ($371 to $227), and higher external costs ($560 to $388). These less dense, less accessible schools had to bus more students a further distance and were unable to afford a highly accessible alternative to bus ridership or passenger vehicles. *Figure 4.6* illustrates variation in school travel costs across three built environment categories in Florida.

Figure 4.6



Florida's densest, most accessible schools were estimated to have a higher total school travel cost than the moderate density schools ($1,121 and $936, respectively). These schools had comparable annual public costs, with the moderate density schools having slightly lower public capital costs per student ($104 to $112) and slightly higher public operating and maintenance costs per student ($217 to $202). The majority of the estimated cost differential is attributable to private costs ($227 to $304) and external costs ($388 to $504). These higher estimated private and external costs for Florida's densest schools is explained by the relatively higher private passenger vehicle and active school travel rates.

4.3 Practitioner Tool

The school travel and siting implication practitioner tool was developed with the intention of enabling school facility, transportation and administrative personnel to compare the estimated school travel costs between different school site locations. Specifically, users may input the school population and percentage of the school population within one-half mile of the school (Step 1) and the tool estimates school travel rates (Step 2) and costs (Step 3) based on input values to produce a total cost estimate of the associated school travel system for a school (Step 4).

Step 1: Facility Planner Variables			
School Facility Planning Inputs			
Yearly VMT	School Bus		
School Population	650		
Percent of Pop w/in 1/2 Mile	50%		
Step 2: School Transportation and Facility Information			
School Transportation System Information			
School Travel Modes	Count		Count
Total Enrollment	650		650
Passenger Vehicle	273		294.45
Pedestrian	158		76.05
Bicycles	8		6.5
Public School Bus	198		256.1
School Bus Data	School Bus VMT	Number of Buses	
	189	6	
Bus Drivers	Number	Annual Pay	
	6	6812	
Crossing Guards	Number	Annual Pay	
	4	6360	
Passenger Vehicle Data	Passenger Vehicle VMT	Passenger Cost/Mile	
	1300	0.2196	
School Facility Infrastructure Information			
Surface Infrastructure	Amount		
Drive - Passenger	71890		
Drive - Bus	38584		
Parking Spots	111		
Sidewalks - Pedestrian	9175		
Sidewalks - Connecting	4371		
Sidewalks - Loading	8597		
Bike Racks	3		
Overhead Lighting	24		
Cost Factors			
		Number of School Days	Number of Tiers
		185	2

Step 3: School Transportation System Cost Estimates			
Public Capital Costs	**Item**	**Cost**	**Modal Cost**
Facility General	Overhead Lighting	$34,958.55	
	Connecting Sidewalks	$18,541.78	
			$53,500.33
Bus Ridership	Bus Drive / Parking	$159,146.28	
	Unloading Sidewalk	$18,234.67	
	Buses	$248,028.59	
	Security	$4,376.98	
	Facility General	$26,750.17	
			$456,536.68
Passenger Vehicle Ridership	Passenger Drive	$296,520.22	
	Unloading Sidewalk	$18,234.67	
	Parking Spots	$99,784.38	
	Facility General	$26,750.17	
			$441,289.44
Pedestrian	Pedestrian Sidewalk	$38,922.13	
			$38,922.13
Bicycles	Bike Racks	$835.66	
			$835.66
		Capital Cost Total	**$991,084.24**
Public Operation + Maintenance Costs	**Item**	**Cost**	**Modal Cost**
Bus Ridership	Bus Driver	$40,577.31	
	Fuel	$17,117.15	
	Infrastructure Maintain	$6,536.39	
	Vehicle Maintain	$43,272.73	
	Insurance Cost	$1,471.74	
	Safety/Tracking	$372.30	
			$109,347.61
Passenger Vehicle Ridership	Infrastructure Maintain	$5,027.99	
			$5,027.99
Pedestrian	Crossing Guard	$26,311.22	
			$26,311.22
Bicycles			$0.00
		O+M Cost Total	**$140,686.82**

External Costs	Item	Cost	Modal Cost
Bus Ridership	Traffic Congestion	$220.08	
	Traffic Service	$244.53	
	Air Pollution	$454.13	
	GHG	$23,055.75	
	Noise	$1,397.32	
	Safety	$11,742.17	
			$37,113.98
Passenger Vehicle Ridership	Traffic Congestion	$817.96	
	Traffic Service	$1,684.04	
	Air Pollution	$962.31	
	GHG	$31,756.19	
	Noise	$0.00	
	Safety	$114,127.71	
			$149,348.21
Pedestrian	Safety	$57,190.18	**$57,190.18**
Bicycle	Safety	$5,396.82	**$5,396.82**
		External Cost Total	**$249,049.19**
Private Costs	**Item**	**Cost**	**Modal Cost**
Passenger Vehicle Ridership	Vehicle Ownership, Maintenance, Insurance	$51,759.61	
	Monetized Value of Driver Time	$90,155.06	**$141,914.66**
		Private Cost Total	**$141,914.66**

Step 4: Total Cost Comparison Table	
Upfront Costs	
Public Capital	$991,084.24
Annual Costs	
Public Operating & Maintain	$140,686.82
Externalities	$249,049.19
Private Costs	$141,914.66

5. Discussion and Conclusion

School travel is a substantial budgetary expense within the United States with estimates of operating costs accounting for $22 billion annually. The results of this study suggest two notable considerations for annual school travel budget estimates. First, the full social costs of school travel extend far beyond existing annual budget allocations, which only cover bus operation and maintenance. Full social cost consideration, which includes annualized costs for the development of school transportation system, private costs for parent drive time and vehicle operation, and externalities of school travel, suggest that public school transportation operating and maintenance costs account for between 21% and 25% of the full social costs associated with school travel. Thus, the annual social costs of school travel may far exceed the estimated budgetary figures; nationally this figure may be as high as $100 billion annually. Second, the social costs of school travel vary significantly based on local built environment characteristics and the policy climate in which school administrations operate.

State-Level Variation: Influence of Policy and Socio-Cultural Factors

Descriptive results indicate significant state-level differences in the school travel systems for schools in North Carolina and Florida. State-level averages of the study schools suggest the two states have differences, notably the difference in school bus ridership (60.3% bus ridership in NC; 28.0% bus ridership in FL). A closer consideration of local built environment density category averages finds similar trends; comparing both the least dense and moderate density schools in the two state samples shows higher bus rates in North Carolina and higher passenger vehicle and active school travel rates in Florida. Due to higher bus ridership rates, the North Carolina schools averaged lower public costs annually.

These state-level differences in school travel rates may imply that legislation outlining the minimum busing distance may have an effect on school travel trends; Florida's legislature requires students to live a minimum of two miles away from a school to qualify for busing unless a hazardous pedestrian environment is identified near the school. Comparatively, North Carolina's legislated minimum school busing qualification distance is less than Florida's, at one and one-half miles. This means that, for example, students living one and three-quarter miles from school would qualify for busing in North Carolina but would be unlikely to do so in Florida.

In addition to state-level policy factors, visits to school sites in the study and comparison of similar school local built environments in the two states suggest that there may be a different culture and set of expectations around traveling to school. Direct comparison of moderately dense schools in Florida and North Carolina reveals that the Florida schools in this category average fewer bus riders (36.2%) and more vehicle passengers (53.8%) and active school travelers (10.0%) than the North Carolina schools (49.2%, 47.3% and 3.4% respectively).

The cost differences estimated in *Table 4-2* suggest a complex school transportation system in both states. For the North Carolina schools, it seems that a history of school busing in the state, which includes advances in school bus routing technology and resultant efficiency gains, has supported the development of an efficient bus environment in which the majority of students travel to school via the school bus. Built environment categorical comparisons with Florida schools appear to support this notion; we observed a majority of school bus riders for North Carolina schools built in more dense, walkable contexts.

The Florida schools show a different school travel landscape and culture. The decreases in busing distances that are associated with increased density and pedestrian accessibility do decrease the public costs of school travel. However, there are also resultant increases in passenger vehicle and active school travel rates, which as discussed can lead to higher private and external costs. These higher private and external costs are observed in the Florida school sample.

Built Environment Variation: The Relationship between School Travel, Density and Accessibility
Comparing the school travel rates and costs across built environment categories within North Carolina and Florida suggest a strong relationship between the residential density and pedestrian accessibility within a half-mile of the school and school travel rates and costs. While these built environment categories do have variance within, the trends presented in *Tables 4-1* and *4-2* appear to clearly support the policy notion that more dense, well connected schools will increase non-motorized school travel and, as a result, decrease public costs. Indeed, observed school travel rates and public cost estimates suggest that the more homes that are accessible to pedestrians within a half mile of school, the more students will walk or bicycle to school and the lower school bus ridership. However, not all would-be bus riders walk or bike to school with increased density and access. The school travel data in these study schools suggest that decreases in bus ridership from increased density and access are related to increases in both active school travel and private vehicle ridership.

Study Limitations
This study selected twenty schools for participation as a beginning exploration of the relationship between local built environment and education policy factors and school transportation system rates and costs. Thus, the study selection is not a representative sample of schools in Florida and North Carolina. For example, this selection was limited to geographically assigned public schools built within the past five years. As a result, the generalization of any findings associated with the study is limited in applicability to geographically assigned schools; non-geographically assigned schools, such as magnet schools and charter schools, face markedly different logistical challenges associated with school travel costs.

In addition to limitations posed by the policy context and characteristics of schools included in the study, there are statistical limitations associated with the size of the study. Moreover, the built environment categories for schools in each state contain only a handful of schools; thus, one or two schools may impact the results substantially. Due to the limitations in school selection, residential densities within a half-mile of study schools were typically in either suburban or rural settings. As a result, urban schools are not well represented in this study.

Lastly, a limitation of this study is the use of North Carolina bus rider, passenger vehicle, and active school travel per trip costs to account for external injury costs in Florida; future studies should evaluate the influence of higher active school travel rates on the reduction of injury costs due to the presence of more pedestrians and bicyclists at and around the school.

Future research should seek to evaluate school transportation system costs for schools beyond recently constructed facilities and consider both non-geographically enrolled schools, like magnet and charter schools, and non-public schools. Future research may pay particular attention to school siting and transportation costs within dense urban contexts. Lastly, the noted differences in travel mode rates and public school transportation costs between North Carolina and Florida schools suggest that it would be useful if to thoroughly consider and explore other contributing factors of active school travel, such as weather patterns and educational policies.

Recommendations
The results of the study suggest several implications for school transportation and facility planning professionals. First, there may be a relationship between pedestrian accessible residential density within a half-mile and public school travel rates and costs; dense, accessible residential areas around schools demonstrate lower levels of annual public transportation costs per pupil. Second, state-level variations in school bus distance eligibility policy suggest that eligibility policies may play a role in school travel mode choice and derived school transportation system costs. Third, programs and policies that seek to address school travel mode choice and school siting will need to tailor solutions to the local context and community.

This inventory of school travel data and estimation of school travel costs presents an opportunity for researchers and practitioners to understand the potential influence of local built environment and education policies on school transportation system form and function. This study contributes to existing school transportation research through the construction of a school transportation system cost inventory that accounts for the full costs of school travel and includes measures of public, private and external costs across all school travel modes.

Appendix A: Participating School Sites in North Carolina and Florida

North Carolina School Sites

School Name	Address	City
Stateside Elementary	132 Stateside Blvd.	Jacksonville
Princeton Elementary	650 Holts Pond Rd	Princeton
Cloverleaf Elementary	300 James Farm Rd	Statesville
Coddle Creek Elementary	484 Presbyterian Rd	Mooresville
Spring Valley Elementary	2051 Northern Durham Prky	Durham
Caleb's Creek Elementary	1109 Salem Crossing Rd	Kernersville
Patriots Elementary	1510 Holden Rd SW	Concord
Rocky River Elementary	473 Rocky River Rd	Mooresville
Lakeforest Elementary	3300 Briarcliff Drive	Greenville
Ridgewood Elementary	3601 South Bend Dr	Winterville
Northeast Elementary	1002 E Highland Ave	Kinston

Florida School Sites

School Name	Address	City
Sorrento Elementary	24605 Wallick Rd	Sorrento
Palencia Elementary	355 Palencia Village Dr	St. Augustine
Marion Oaks Elementary	280 Marion Oaks Trail	Ocala
Bartram Springs Elementary	14799 Bartram Springs Trail	Jacksonville
Koa Elementary	5000 Koa St	Kissimmee
Forsyth Woods Elementary	6651 Curtis Trail	Orlando
Wetherbee Elementary	701 E. Wetherbee Rd	Orlando
Waterleaf Elementary	450 Kernan Blvd N	Jacksonville
Sunridge Elementary	14455 Sunridge Blvd	Winter Garden

Appendix B.

Transportation Cost Item Worksheet: Facility Planning and Transportation Staff					
Each cost item is referring to the new or additional expenditures created by the opening of this school. Most cost items will require both the actual dollar amount expended for a particular item as well as certain standardized descriptive features of a cost item. This will allow the researchers to both understand the actual costs associated with each item at a particular school facility as well as give a standardized measure of the extent of each item to allow different facilities to be compared without the variation in local material and labor costs. A notes field is provided to record anything that may warrant discussion in the interview. If a particular cost item is not present at your facility, simply write NA in the Response column. Thank you again for your cooperation in this survey.					
Code	**Question**	**Cost Item**	**Response Category**	**Response**	**Notes**
Roadway Construction					
bg	1.1	In addition to the land parcel that the school sits on, did the school acquire land to use for roads?	(y/n)		n = Skip to Question 2.1
1.1.1	1.2	If so, how much land was necessary for the road (sq ft)?	(numerical)		
1.1.1	1.3	How much did the land (ROW) acquisition cost?	(numerical)		
bg	1.4	What was the width of the road constructed?	(numerical)		
1.1.2.1	1.5	How many feet (linear) of road were constructed?	(numerical)		
1.1.2.1b	1.6	How many feet (linear) were added to already existing roadway?	(numerical)		
bg	1.7	Does the road construction include a shared roadway and/or shared lane markings?	(y/n)		n = Skip to Question 1.9
1.1.2.2a	1.8	How many feet (linear) of the road includes shared lane markings?	(numerical)		
bg	1.9	Does the road include a bicycle lane?	(y/n)		n = Skip to Question 2.1
1.1.2.2b	1.10	How many feet (linear) of the road includes a bicycle lane?	(numerical)		

Separated Pedestrian and Bicycle Facilities					
bg	2.1	Does the school have a shared use path?	(y/n)		n = Skip to Question 3.1
1.1.2.2c	2.2	How many feet (linear) of shared use path were constructed at and around the school for the project?	(numerical)		

Traffic Signals					
bg	3.1	How many traffic signals were installed at intersections at or near the school?	(numerical)		0 = Skip to Question 3.3
bg	3.2	Of these, how many of the installed signals included lane control (Right / Left Turn)?	(numerical)		
1.1.3d	3.3	Did the school add left turn functionality to an existing traffic signal?	(y/n)		n = Skip to Question 3.5
1.1.3e	3.4	If so, how many?	(numerical)		
bg	3.5	Did the school install pedestrian activated mid-block crossing traffic signals?	(y/n)		n = Skip to Question 3.7
1.1.3a	3.6	If so, how many?	(numerical)		
bg	3.7	Did the school install any "school zone" signals?	(y/n)		n = Skip to Question 4.1
1.1.3b	3.8	If so, how many?	(numerical)		

Lighting: School Entrance and Parking Lot					
1.3.4	4.1	How many overhead lights did the school install at the entrance, drive, and parking lot?	(numerical)		

Parking					
1.3.2	5.1	How many bicycle racks were installed at the school?	(numerical)		

Campus Security					
4.1	6.1	Does the school use a security system (video monitoring) to monitor the school parking lot and drop/off pickup zones?	(y/n)		n = Skip to End
4.1	6.2	How much did the security system cost to install?	(numerical)		
4.2	6.3	How much is spent annually maintaining the security system at the school?	(numerical)		

Bus Routes					
bg	1.1	How many buses serve the school?	(numerical)		
bg	1.2	How many routes serve the school?	(numerical)		
5.1a-b 5.2	1.3	How many total miles are driven by all buses serving the school on a normal school day (including deadhead mileage)?	(numerical)		Available from TD1 Report for Route Mileage of School
bg	1.4	Does your school district employ tiered school start times?	(y/n)		
bg	1.5	If yes, how many tiers?	(numerical)		1 tier = 1 school; 2 tier = 2 school; 3 tier = 3 schools (max)
1.3	1.6	How much, on average, does it cost to acquire a new bus for the district?	(numerical)		

Student Travel Mode Splits					
bg	2.1	How many students attend the school?	(numerical)		
bg	2.2	Based on available district transportation information, about how many students ride the bus at the school?	(numerical)		
bg	2.3	About how many students	(numerical)		

		are driven to school?			
bg	2.4	About how many students walk to school?	(numerical)		
bg	2.5	About how many students bike to school?	(numerical)		

Bus Drivers					
2.1.1a	3.1	On average how much per year is a driver's compensation, including benefits?	(numerical)		
2.1.1a add-on	3.2	How much is spent annually on training per bus driver?	(numerical)		

Bus Security + Tracking					
4.1	4.1	Does the school use a security system (video monitoring) to monitor the school bus?	(y/n)		n = Skip Q4.4
4.1	4.2	Were these security features included in the cost of the bus?	(y/n)		
4.1	4.3	How much did they cost to install?	(numerical)		
4.2	4.6	How much is spent annually monitoring and maintaining onboard security per bus?	(numerical)		
4.3	4.4	Do the buses use GPS tracking units?	(y/n)		
4.3	4.5	If yes, how much did they cost to install?	(numerical)		
4.3	4.6	If yes, how much is the monthly data tracking service, per bus?	(numerical)		

Financing					
bg	5.1	How much is spent annually on interest for loans from the school district's transportation department total?	(numerical)		
2.1.3	5.2	How much is spent annually on interest from loans for bus facilities and buses needed to serve the school?	(numerical)		

2.1.3	5.3	How much do the bus facilities and buses depreciate annually (in dollars per facility or bus)?	(numerical)		

Liability					
bg	6.1	How much is spent annually to insure and license all the buses in the district?	(numerical)		
2.1.4	6.2	How much is spent annually to insure and license the buses and bus facilities which serve the school?	(numerical)		

Crossing Guards					
2.1.1b	1.1	How many crossing guards serve the school?	(numerical)		0 = Skip to End
2.1.1b	1.2	On average how much per year is a crossing guard's compensation, including benefits?	(numerical)		
2.1.1b add-on	1.3	On average how much is spent on crossing guard equipment annually?	(numerical)		
2.1.1b add-on	1.4	How much is spent annually on training per crossing guard?	(numerical)		

Appendix C

Florida Home-to-School Distance Estimation
Florida schools included in this study did not have access to data on the home location of 2012-2013 students. However, data with the locations of elementary students during the 2007-08 school year for Hillsborough, Orange, Pasco and Seminole counties were available. Driving distances for 208,470 students (2007-08) were calculated using ArcGIS 10.0. Orange County data did not include the school attended, so it was assumed that students attended the school whose 2013 school attendance zone (SAZ) they were located in.

Average driving distances from home to school for students in each of the 333 elementary schools were calculated using 2007-08 data. School travel distance by private vehicle was determined using the size of the school's attendance zone in acres and the housing unit density within a mile of each school. This model has an adjusted R-square of .335, and the t statistic of D and A were -7.788 and 6.768, respectively.

$$Average\ Driving\ Distance = \mathbf{2.678} - \mathbf{.455}\boldsymbol{Density} + \left(\mathbf{2.908} \times \mathbf{10^{-5}}\right)\boldsymbol{SAZ}$$

Nine schools in Seminole County were located in school attendance zones with more than one school available for students to choose from. The model including schools with shared SAZs was selected because one of the study schools, Sorrento, is itself in a shared SAZ.

School Name	Predicted Driving Distance w/o Shared SAZ School Data	Predicted Driving Distance w/ Shared SAZ School Data
Koa	2.43	2.43
Forsyth Woods	1.70	1.69
Wetherbee	2.52	2.52
Waterleaf	1.96	1.96
Bartram Springs	3.03	3.04
Sorrento	3.43	3.46
Palencia	3.45	3.48
Marion Oaks	3.16	3.18
Sunridge	2.37	2.37

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